REMARKS

By this amendment, Applicants have amended the claims to more clearly define their invention. In particular, claims 1 and 2 have been canceled and claim 4 amended. Claim 4 has been amended to recite that the interface separates an upstream zone and downstream zone. See, e.g., page 10, lines 20-21 of Applicants' specification. Claim 4 has also been amended to clarify the manner in which the stage "selecting at least one layer of the stratified hydrocarbon reservoir where an interface between the fluid in place and a flushing fluid moves in a stationary manner" is carried out. In particular, claim 4 has been amended to recite the steps of evaluating a pressure $p_1(z)$ at the interface for the upstream zone, evaluating a pressure $p_2(z)$ at the interface for the downstream zone, and calculating a pressure jump at any point of the interface from the pressures $p_1(z)$ and $p_2(z)$. The step of iteratively changing the form of the interface has been clarified to indicate that the form of the interface is changed to minimize the pressure jump until the jump is below a defined critical value in at least one part of the interface, the part defining at least one layer. These amendments to claim 4 are supported by, e.g., the description at page 12, line 7 to page 13, line 10 of Applicants' specification. Applicants have also added new claim 6 to define further aspects of the present invention. Claim 6 is supported by, e.g., page 11, line 15 to page 12, line 6 and page 14, lines 3-5 of Applicants' specification.

The foregoing amendments are necessary in order to respond to the new grounds of rejection in the outstanding Office Action. Moreover, the

foregoing amendments place the application in condition for allowance for the reasons set forth hereinafter or, in better form for consideration on appeal. Therefore, entry of this amendment under 37 CFR 1.116 is requested.

In view of the cancellation of claims 1 and 2, the rejection of these claims under 35 U.S.C. 101 is moot.

Likewise, the rejection of claims 1 and 2 under 35 U.S.C. 102(b) as being anticipated by Popinet et al. is moot.

Claims 1, 2, 4 and 5 stand rejected under 35 U.S.C. 112, first paragraph, as alleging failing to comply with the enablement requirement. Applicants traverse this rejection and request reconsideration thereof.

As pointed out on page 1, lines 5-7 of Applicants' specification, the present invention relates to a method for determining in a <u>stratified porous medium</u> (hydrocarbon reservoir) wherein the front or interface between fluids in place and flushing fluids moves in a stationary manner, i.e., <u>without deformation</u> and at constant velocity.

The example given by the Examiner in numbered sections 8 and 9 of the Office Action is not applicable to a <u>stratified porous medium</u>; it is only applicable to fluid directly in contact, such as a bubble (see Summary). The method of Popinet is dedicated to problems involving a moving interface in a multiphase fluid flow (see introduction of Popinet). In this context, the motion of fluids is described by the Navier-Stokes equations. These are the used by Popinet. In the context of stratified porous medium, the motion of fluids is described by the Darcy equation.

The Examiner notes the terms "porous" and "Darcy equation" are not

recited in the claims. However, the use of "stratified hydrocarbon reservoir" in the claim tells one skilled in the art that the medium is porous and that the Darcy equation is used rather than Navier and Stoke. It can be found in all literature concerning oil and gas industry.

A reservoir is a porous medium; a reservoir cannot contain any hydrocarbon without pores. A stratified hydrocarbon reservoir is not a hole filled with hydrocarbon. The hydrocarbons are contained in the pores of a porous rock.

The Examiner now refers to elements of Karlsen. However, Karlsen is dedicated to porous medium, using Darcy equation. This does not imply that Popinet uses the same. As mentioned above, the figure of Popinet does not concern the technical domain of the invention; the physics are not the same.

The figure chosen by the Examiner clearly indicates a deformation of the interface. This is in contradiction with the present invention, in which the interface between fluids in place and the flushing fluids moves in a stationary manner, i.e. without deformation and at constant velocity.

One skilled in the art knows how to chose an *a priori* interface form in the claimed conditions i.e., a stratified porous medium and a front without deformation. The surface t=0.9 cannot correspond to a surface of a front in a stratified porous medium wherein the front or interface between fluids in place and flushing fluids moves in a stationary manner, i.e., without deformation and at constant velocity.

In sections 37 and 38 of the office action, the Examiner considers a vortex and complex front, such as those associated with sources and sinks in

fluid flow. However, the present invention is clearly attached to the domain of recovery of a hydrocarbon fluid in a stratified hydrocarbon reservoir. Therefore, the Examiner should attempt to propose an example in this domain, i.e., a vortex in a stratified hydrocarbon reservoir due to an injection of a flushing fluid. Applicants think it is not possible.

While the Examiner refers to Rayleigh-Taylor instabilities, if a dense viscous layer rests on top of a less dense viscous layer, the lower layer will become unstable and form a Rayleigh-Taylor instability. However, in the present application, as it is well known to those skilled in the art, the interface is not sub-horizontal, but sub-vertical (see page 11, line 16: "it moves horizontally"). Therefore, the Rayleigh-Taylor instabilities can not occur in the context of enhanced oil recovery in a porous reservoir.

As to section 12 of the Office Action, claim 4 has been amended to clarify the stage of selecting at least one layer of the stratified hydrocarbon reservoir where an interface between the fluid in place the flushing fluid moves in a stationary manner. Specifically, claim 4 has been amended to recite the steps evaluating a pressure $p_1(z)$ at the interface of the upstream zone, evaluating a pressure of $p_2(z)$ at the interface for the downstream zone, and calculating a pressure jump at any point of the interface from the pressures $p_1(z)$ and $p_2(z)$.

In sections 39-41 of the office action, the Examiner persists in taking an example in an area far from the field of the present invention. Stationary Bernoulli flow in a pipe can not occur in stratified hydrocarbon reservoir. A stratified reservoir not a pipe. It is not only a question of object, it is a

question of physics. A fluid does not flow in a pipe as it does through pores of a porous medium.

According to the present invention, Applicants make an hypothesis: the conditions are stationary. Under these conditions, Applicants develop a methodology. If Applicants find a contradiction, they have to reconsider the hypothesis. It is common to work as such. It is only a hypothesis of work.

In addition, as noted at line 12 et seq. of Applicants' specification, page 8:

> <u>The front being assumed to be stationary,</u> the flow is known at the interface and we therefore have a perfectly defined Neumann problem to solve for reach of the two zones separated by the interface. The pressure field can <u>therefore</u> <u>be solved</u> <u>independently</u> in the two regions. We then evaluate the pressure jump on either side of the interface, an any point thereof. (Emphasis added.)

In other words, the hypothesis leads Applicants to consider that they can estimate pressure independently in two regions separating the interface.

The pressure is evaluated on each side of the interface, with type types of equation (see page 12):

For the downstream zone: $\nabla\left(\frac{K_1(z)}{\mu_1}(\rho_1 g - \nabla p)\right) = 0$

For the upstream zone: $\nabla\left(\frac{K_2(z)}{\mu_2}(\rho_2 g - \nabla p)\right) = 0$

The upstream zone and the downstream zone include the interface.

If the hypothesis is right, the two equations should give the same result at the interface (the only part in common). If not, the hypothesis is wrong.

If the two equations do not give the same result at the interface, it means the two pressures should have not been calculated independently. The assumption “the front being assumed to be stationary,” has to be reconsidered. See, page 11, lines 11 and 12 of Applicants’ specification.

Applicants submit their specification clearly enables those skilled in the art to carry out the invention as described above. The examples given by the Examiner relate to a different field and do not call into question the enabling character of Applicants’ specification. Accordingly, Applicants’ specification complies with requirements of 35 U.S.C. 112, first paragraph.

Claims 1, 2, 4 and 5 stand rejected under 35 U.S.C. 102(b) as being clearly anticipated by Karlsen et al. Applicants traverse this rejection and request reconsideration thereof.

The present invention concerns a method for optimizing the recovery of a hydrocarbon reservoir. In order to manage the recovery, the invention uses an EOR (Enhanced Oil Recovery) method. Such a method consists in flushing the reservoir by injecting a flushing fluid. The flushing fluid is driving the hydrocarbon fluid to be recovered into a production well. To better improve this EOR method, the invention allows to determine the viscosity of the flushing fluid which allows to optimize the recovery. In order to determine this viscosity, the invention selects the viscosity which optimizes the stationary displacement in the reservoir. In order to optimize the stationary displacement in the reservoir, Applicants apply an iterative process based on

the equalization of pressures on the front, computed by two different equations. Karlsen discloses a front-tracking approach to two-phase fluid-flow model. The problem solved by Karlsen is to take account the capillary forces in front-tracking modeling. The medium concerned by this document is an oil reservoir, therefore a porous medium. Consequently, Karlsen uses, as does the present invention, the Darcy law in order to determine the pressure (Equation (6) of Karlsen is equivalent to the equations on page 12, lines 9 and 11). However, Karlsen does not disclose the determination of the viscosity of the flushing fluid which allows to optimize the recovery.

The Examiner alleges the contrary by citing very large part of the document: pages 5-13, 22-26. However, these portions do not appear to disclose the selection of a viscosity of fluid dedicated to Enhanced Oil Recovery method. In Karlsen, the viscosity of water is denoted μ_w and the viscosity of oil is denoted μ_o (page 6, lines 9 and 10). Neither these viscosities are <u>determined</u>.

Karlsen does not disclose an iterative method wherein the pressure on the front is computed independently in the downstream zone and in the upstream zone.

Karlsen does not disclose an iterative method including minimizing the different between the pressures on the front computed independently in the downstream zone and in the upstream zone.

For the foregoing reasons, the Karlsen et al. reference does not disclose the presently claimed invention.

Claims 4 and 5 stand rejected under 35 U.S.C. 103(a) as being

unpatentable over Popinet et al. in view of Karlsen et al. and Sheldon et al. Applicants traverse this rejection and request reconsideration thereof.

Popinet et al. discloses a front-tracking algorithm for the solution of the 2D incompressible Navier-Stokes equations (see summary).

A method dedicated to study flow of a fluid into another fluid is not applicable to study the flow of a fluid in a porous medium. A stratified reservoir is a porous medium. It can be easily seen through the equations; according to the present invention, the pressure is computed from permeability of the medium. Popinet does not take account the characteristic of the medium (since there is no medium).

Popinet does not disclose the determination of the viscosity of the flushing fluid which allows to optimize the recovery.

On page 786 of Popinet, “the viscous correction” does not correspond to a determination of the viscosity of the flushing fluid (there is no flushing fluid in Popinet). It corresponds to a modified equation.

In Popinet, the viscosity of water is denoted μ (page 777, line 9). This viscosity is not determined. Equation (6) does not allow to compute viscosity; in any event, it would not be an iterative method.

Popinet does not disclose an iterative method wherein the pressure on the front is computed independently in the downstream zone and in the upstream zone.

Popinet does not disclose an iterative method including minimizing the difference between the pressures on the front computed independently in the downstream zone and in the upstream zone. The Examiner cites “pressure

gradient correction” in Popinet. However, this pressure gradient correction is used when a pressure jump necessitates a better approximation, not an equalization.

Finally, Karlsen and Popinet do not disclose:

a) selecting at least one layer of the stratified hydrocarbon reservoir where an interface between the fluid in place and a flushing fluid moves in a stationary manner, the interface separating an upstream zone and a downstream;

b) modifying the said reservoir model by assigning mean hydrodynamic properties uniformly to the at least one layer; and

c) determining a viscosity of the flushing fluid which allows to optimize the recovery, by selecting the viscosity which optimize the stationary displacements in said hydrocarbon reservoir, by using the said model.

While the Examiner cites the Sheldon et al. reference as alleging disclosing that the solution of moving interface problems is important in predicting the behavior of oil reservoirs under various conditions of production, it is submitted nothing in Sheldon et al. remedies any of the basic deficiencies noted above with respect to Popinet et al. and Karlsen et al. Accordingly, the presently claimed invention is patentable over the proposed combination of references.

In view of the foregoing amendments and remarks, entry of this amendment and favorable reconsideration and allowance of all of the claims now in the application are requested.

Please charge any shortage in the fees due in connection with the filing of this paper, to the deposit account of Antonelli, Terry, Stout & Kraus, LLP, Deposit Account No. 01-2135 (Case: 612.45186X00), and please credit any excess fees to such deposit account.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

/Alan E. Schiavelli/
Alan E. Schiavelli
Registration No. 32,087

AES/at
(703) 312-6600